Pieter Naaijkens

CURRICULUM VITAE[1]

PERSONAL INFORMATION

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ACADEMIC EMPLOYMENT

1/2020 –	*Lecturer in Mathematical Physics* Cardiff University
11/2018 – 1/2020	*Senior postdoc* ERC project "GAPS" (P.I.: David Pérez-García) Universidad Complutense de Madrid
9/2015 – 10/2018	*Marie Skłodowska-Curie Individual Fellow (Global Fellowship)* UC Davis (mentor Prof. Bruno Nachtergaele), 2015–2017 RWTH Aachen University (mentor Prof. Barbara Terhal), 2017–2018
4/2012 – 8/2015	*Scientific assistant* (two years as Rubicon fellow) Leibniz University Hannover Mentors: Prof. Tobias Osborne and Prof. Reinhard Werner
10/2007 – 1/2012	*PhD Candidate* Radboud University Nijmegen Supervisors: Prof. Klaas Landsman and Dr. Michael Müger

EDUCATION

10/2007 – 1/2012	*PhD*, Radboud University Nijmegen Thesis: *Anyons in infinite quantum systems: QFT in d=2+1 and the Toric Code* Supervisors: Prof. Klaas Landsman and Dr. Michael Müger Defended on May 15, 2012
9/2001 – 8/2012	*MSc Mathematics* and *MSc Theoretical Physics*, Utrecht University MSc Thesis: *Four-point functions of $N = 4$ SYM_4 in the AdS/CFT correspondence* Supervisor: Dr. Gleb Arutyunov. Grade 8.5/10 Kleine scriptie (~ BSc thesis): *Cartesisch gesloten deelcategorieën van* ***Top*** [Cartesian closed subcategories of **Top**] Supervisor: Dr. Jaap van Oosten. Grade 9.5/10

[1] Last updated: October 2023

GRANTS AND AWARDS

- London Mathematical Society "Joint Research Groups" (Scheme 3) grant "Algebraic Quantum Field Theory in the UK", 2023–ongoing
- Welsh Government *Taith* research mobility funding: 1x incoming (Canada), 1x outgoing (Germany), 2024–2025.
- AHP Prize 2016, for the most remarkable paper published in Annales Henri Poincaré
- EU Marie Skłodowska-Curie Actions-Individual Fellowship, 2015–2018. Project: *Operator Algebraic Approach to Topological Phases*
- Netherlands Organisation for Scientific Research (NWO) Rubicon, 2012–2014. Project: *Mathematical structure of anyons in planar quantum spin systems*

RESEARCH INTERESTS

I am interested in quantum spin systems and their applications to quantum information theory, with a focus on the use of functional analysis and operator algebraic techniques. I primarily study quantum spin systems with topological order, for example how one can obtain a full understanding of the (quasi)particle excitations of such systems. The properties of these excitations can be described by tensor categories, and an important part of my work is related to how one can obtain this tensor category by studying certain representations of the C^*-algebra of quasi-local observables. A particularly interesting question is then how stable this structure is with respect to perturbations of the underlying dynamics defining the system, which also is relevant in the classification of topological phases. I am also interest in applications to quantum information, for example how one can use subfactor theory to describe channel capacities.

PUBLICATIONS

Refereed journals and proceedings

1. A. Bols, M. Hamdan, P. Naaijkens, S. Vadnerkar: The category of anyon sectors for non-abelian quantum double models (2025). arXiv:2503.15611
2. C. Jones, P. Naaijkens, D. Penneys, D. Wallick: Local topological order and boundary algebras. Preprint, to appear in *Forum of Mathematics, Sigma* (2023) arXiv:2307.12552
3. P. Naaijkens, Y. Ogata: The split and approximate split property in 2D systems: stability and absence of superselection sectors. *Commun. Math. Phys.* **932**:921-950 (2022) arXiv:2102.07707
4. K. Kato, P. Naaijkens: An entropic invariant for 2D gapped quantum phases, *J. Phys. A: Math. Theor.* **53**:085302 (2020) arXiv:1810.02376
5. M. Cha, P. Naaijkens, B. Nachtergaele: On the stability of charges in infinite quantum spin systems, *Commun. Math. Phys.* **373**:219–264 (2020) arXiv:1804.03203
6. P. Naaijkens: Subfactors and quantum information theory. *In:* F. Bonetto, D. Borthwick, E. Harrell, M. Loss (eds): Mathematical Problems in Quantum Physics, AMS *Contemporary Mathematics* **717**, pp. 257–280 (2018) arXiv:1704.05562
7. M. Cha, P. Naaijkens, B. Nachtergaele: The complete set of infinite volume ground states for Kitaev's abelian quantum double models, *Commun. Math. Phys.* **357**:125–157 (2018) arXiv:1608.04449
8. L. Fiedler, P. Naaijkens, T.J. Osborne: Jones index, secret sharing and total quantum dimension, *New J. Phys.* **19**:023039 (2017) arXiv:1608.02618
9. S. Bachmann, W. Dybalski, P. Naaijkens: Lieb-Robinson bounds, Arveson spectrum and Haag-Ruelle scattering theory for gapped quantum spin systems, *Ann. Henri Poincaré* **17**:1737–1791 (2016) **Note:** awarded with **AHP Prize 2016**. arXiv:1412.2970
10. L. Chang, M. Cheng, S.X. Cui, Y. Hu, W. Jin, R. Movassagh, P. Naaijkens, Z. Wang, A. Young: On Enriching the Levin-Wen model with Symmetry, *J. Phys. A: Math. Theor.* **48**:12FT01 (2015) arXiv:1412.6589

11. L. Fiedler, P. Naaijkens: Haag duality for Kitaev's quantum double model for abelian groups, *Rev. Math. Phys.* **27**:1550021:1–43 (2015) arXiv:1406.1084
12. P. Naaijkens: Kosaki-Longo index and classification of charges in 2D quantum spin models, *J. Math. Phys.* **54**:081901-1–17 (2013). **Note:** selected as "**editor's pick**". arXiv:1303.4420
13. P. Naaijkens: Haag duality and the distal split property for cones in the toric code, *Lett. Math. Phys.* **101**:341–354 (2012) arXiv:1106.4171
14. P. Naaijkens: Localized endomorphisms in Kitaev's toric code on the plane, *Rev. Math. Phys.* **23**:347–373 (2011) arXiv:1012.3857
15. P. Naaijkens: On the extension of stringlike localised sectors in 2+1 dimensions, *Commun. Math. Phys.* **303**:385–420 (2011) arXiv:1004.4775
16. P. Naaijkens: Topologische kwantumcomputers: rekenen met vlechten, *Nieuw Arch. Wiskd.* **11**:187–193 (sept. 2010)
17. L. Berdichevsky, P. Naaijkens: Four-point functions of different-weight operators in the AdS/CFT correspondence, *JHEP* **0801**:071 (2008) arXiv:0709.1365

Books and book chapters

18. Quantum Spin Systems on Infinite Lattices: A Concise Introduction, *Lecture Notes in Physics* **933**, Springer International Publishing (2017) arXiv:1311.2717
19. Kitaev's quantum double model from a local quantum physics point of view. In: R. Brunetti C. Dappiaggi, K. Fredenhagen, J. Yngvason (eds), Advances in Algebraic Quantum Field Theory, pp. 365–395, Springer (2015) arXiv:1508.07170

TEACHING

As instructor:

- MA2008 *(Linear Algebra II)* 2023/24 – ongoing. (With Ian Charlesworth)
- MA4016 *(Quantum Information Theory)*, 2020/21 – 2024/25.
- MA2003 *(Complex Analysis)*, 2019/20–2022/23.
- *Quantum Information*, Summer semester 2018 (with David DiVincenzo)
- *MAT-22A (Introduction to Linear Algebra)*, Spring quarter 2016.
- *Quantum spin systems on infinite lattices*, Summer semester 2013.
- *Zomercursus wiskunde*. Crash course for prospective students not meeting admission requirements for mathematics and physics. I could recommend students for admission after successful completion of the course. Summer 2008.
- Various lectures (including preparing materials) for high school students aged 12–18 in the *Sprint-Up* programme. Topics included for example fractals and infinity, 2008–2010.

As teaching assistant:

- *Lie-Algebren und ihre Darstellungen in der Physik* [Lie Algebras and their representations in physics], Summer semester 2014
- *Ergänzungen zur klassischen Physik* [Advanced classical physics], Fall semester 2012
- *Symmetry Breaking*, Spring 2011
- *Inleiding Fourieranalyse* [Introduction to Fourier analysis], Spring 2010
- *Topologie* [Topology], Fall 2009
- *Introduction to partial differential equations*, Spring 2009
- *Analysis I*, Spring 2008

Student supervision:

- Naomi Wray (PhD). October 2023 – ongoing

- Mahdie Hamdan (PhD). October 2020 – August 2024. *Infinite Volume Ground States in the non-Abelian Quantum Double Model*. Defended 25 November 2024
- Leander Fiedler (PhD). Co-supervision with Prof. Reinhard Werner, referee for thesis. *Haag duality and Jones-Kosaki-Longo index in Kitaev's quantum double models for finite abelian groups*. Defended January 18, 2017
- Vanshaj Bindal (MSc Physics) *Holographic Quantum Error Correction*, September 2024
- Lewis Kordell (MMath), *A Study in Classifying Quantum Cellular Automata*, May 2024
- Jay Hedger (MMath), *Holography and Quantum Error Correction*, May 2022
- Deniz Stiegemann (MSc). Co-supervision with Prof. Tobias Osborne. *Many-Body Localization and Spectral Theory*, October 2015

RESEARCH VISITS

International research visits and programmes (of one week or longer):

- Oberwolfach, 27 July–1 August, 2025
- Caltech, October 28–November 1, 2019
- University of Tokyo, November 22–December 8, 2017
- Station Q/UC Santa Barbara, May 1–5, 2017
- AMS Mathematical Research Communities on fusion categories and topological quantum computation, Snowbird (UT), USA, June 23–30, 2014
- Workshop ESI programme on "Operator algebras and conformal field theory", Vienna, Austria, September 8–19, 2008

INVITED TALKS

- Invited lecture series, Twinned workshop on "Quantum Field Theory and Topological Phases via Homotopy Theory and Operator Algebras", Max-Planck-Institut für Mathematik, Bonn, Germany, 30 June 2025 – 11 July 2025
- Graduate lecture at LMS South West and South Wales Regional Meeting, Cardiff, 14 May 2025
- Quantum groups, tensor categories and quantum field theory, Universitet i Oslo, Norway, 13 January 2025
- Invited lecture series: C^*-Algebraic Quantum Mechanics and Topological Phases of Matter, CU Boulder, Colorado, 29 July – 2 August 2024
- AQFT in the UK 8, York, UK, 27 June 2024
- Quantum Mathematics Seminar, Nottingham, UK, 13 March 2024
- Twinned Conference on C^*-Algebras and Tensor Categories, ICMS, Edinburgh, UK, 6 November 2023
- Functional Analysis Seminar, Oxford, 31 October 2023
- Subfactor seminar, Vanderbilt (online), 27 October 2023
- Interfaces Between Quantum and Classical Statistical Mechanics, São Paulo, Brazil, 25 July 2023
- Focus week: Quantum Many Body Systems and Quantum Information, ICMAT, Madrid, Spain, 14 March 2023
- Mathematische Physik Seminar, FAU Erlangen, Germany, 24 November 2022
- University Quantum Symmetries Lectures, Online, 4 October 2021
- IWOTA 2021: Operator Algebras in Quantum Theory session, Lancaster, UK, 20 August 2021
- Virtual Workshop C*-algebras, K-theories and Noncommutative Geometries of Correlated Condensed Matter Systems, Simons Center for Geometry and Physics / Online, 17 May 2021
- Tokyo-Kyoto Joint Online Operator Algebra Seminar, Online, 11 May 2021
- AQFT UK meeting, Lancaster, 20 February 2020
- Geometry and Physics seminar, Caltech, 29 October 2019
- Workshop "Analytical and combinatorial methods in quantum information theory", ICMS, Edinburgh, UK, 9–13 September 2019

- Mathematics of Quantum Information Theory, Lorentz Center, Leiden, The Netherlands, 8 May 2019
- Workshop "Operator algebras and groups I", ICMAT, Madrid, 21 March 2019
- Workshop "Quantum Information and Operator Algebras", Rome, 15–16 February 2018
- Condensed Matter Theory seminar, University of Cologne, 18 December 2017
- Workshop "Algebraic Structures and Quantum Physics", Cardiff, 14–15 December 2017
- Operator Algebra Seminar, University of Tokyo, 4 December 2017
- Quantum Algebra and Topology Seminar, UC Santa Barbara, 3 May 2017
- Subfactor seminar, Vanderbilt, Nashville TN, 14 April 2017
- QMath13 (New topics session), Atlanta, GA, 9 October 2016
- Entanglement in Quantum Spin Systems, Simons Center, Stony Brook NY, 3 October 2016
- 34th Western States Meeting, Caltech, 16 February 2016
- Mathematical Physics and Probability seminar, UC Davis, October 21, 2015
- Quantum Spin Systems workshop, Cergy-Pontoise, France, June 24, 2015
- Born-Hilbert seminar, Göttingen, Germany, January 26, 2015
- Mathematical Physics and Probability seminar, UC Davis, January 14, 2015
- AMS Joint Mathematics Meeting, MRC session, San Antonio, TX, January 11, 2015
- Group seminar RWTH Aachen, Germany, September 4, 2014
- NSF/CBMS Conference on Quantum Spin Systems, Birmingham, AL, June 19, 2014
- Bonn-Köln-Algebra Seminar, Cologne, Germany, October 29, 2013
- Group Seminar Free University Berlin, Germany, August 27, 2013
- NTH Colloquium, Braunschweig, Germany, May 24, 2012
- Ph.D. Colloquium, Utrecht University, The Netherlands, June 23, 2010
- Oberseminar C^*-Algebren, Münster, Germany, February 2, 2010
- EIDMA Seminar, Eindhoven, The Netherlands, May 20, 2009

CONTRIBUTED TALKS

- Operator Algebras: Subfactors, K-theory, Conformal Field Theory, Gregynog, Wales, 28 July 2022
- QMath 14 (Many-Body Systems session), Aalborg, Denmark, August 15, 2019
- QMAP Seminar, UC Davis, January 27, 2017
- DPG Frühjahrstagung, Berlin, Germany, March 18, 2015
- DPG Frühjahrstagung, Berlin, Germany, March 20, 2014
- Poster. QIP 2014, Barcelona, Spain, February 3, 2014
- DPG Frühjahrstagung, Jena, Germany, February 28, 2013
- Poster. Benasque symposium on topological quantum information, Spain, February 14, 2013
- Young Researcher Symposium, International Congress on Mathematical Physics, Aalborg, Denmark, August 4, 2012
- 28th workshop on foundations and constructive aspects of QFT, Göttingen, Germany, July 2, 2011
- 27th workshop on foundations and constructive aspects of QFT, Leipzig, Germany, November 20, 2010
- 25th workshop on foundations and constructive aspects of QFT, Göttingen, Germany, January 15, 2010
- Mathematics staff colloquium, Nijmegen, May 27, 2009
- Philips mathematics award session, Dutch Mathematical Congress, Groningen, The Netherlands, April 15, 2009
- Seminar on quantization, non-commutative geometry and symmetry, Nijmegen, The Netherlands, February 2, 2008
- Seminar on quantization, non-commutative geometry and symmetry, Nijmegen, The Netherlands, January 22, 2008

SELECTED CONFERENCES, WORKSHOPS AND SUMMER SCHOOLS ATTENDED

- Workshop "Mathematics of Quantum Information Theory", Lorentz Center, Leiden, The Netherlands, 6–10 May, 2019

- Thematic programme "Operator Algebras, Groups and Applications to Quantum Information", ICMAT, Madrid, March 11–June 29, 2019
- Workshop "Operator algebras and groups I", ICMAT, Madrid, 21 March 2019
- Workshop "Operator algebras and quantum information", Institut Henri Poincaré, Paris, September 10–14, 2017
- Workshop "Entanglement in Quantum Spin Systems", Simons Center, Stony Brook, NY, October 3–7, 2016
- Workshop "Quantum spins", Cergy-Pontoise, France, June 22–24, 2015
- AMS Joint Mathematics Meetings, San Antonio, TX, January 10–13, 2015
- AMS Mathematical Research Communities "Mathematics of Quantum Phases of Matter and Quantum Information", Snowbird, UT, June 23–30, 2014
- NSF/CBMS conference on Quantum Spin Systems, Birmingham, AL, June 16–20, 2014
- Quantum Information Processing 2014, Barcelona, Spain , February 3–7, 2014
- QMath 12, Berlin, Germany, September 10–13, 2013
- Benasque symposium on topological quantum information, Benasque, Spain, February 12–16, 2013
- International Congress on Mathematical Physics, Aalborg, Denmark, August 3–11, 2012
- Mathematical Aspects of QFT and Quantum Statistical Mechanics, Hamburg, Germany, July 30–August 1, 2012
- Workshop "Topological Quantum Computing", Simons Center, Stony Brook, NY, September 12–16, 2011
- Conference on Quantum Groups, Clermont-Ferrand, France, August 30–September 3, 2010
- International Congress on Mathematical Physics, Prague, Czech Republic, August 3–8, 2009
- AQFT: The first 50 years, Göttingen, Germany, July 29–31, 2009
- Summer school "Operator algebras and their applications", Lisbon, Portugal, June 15–19, 2009
- DIAMANT meets GQT workshop, Leiden, The Netherlands, October 27–31, 2008
- Workshop ESI programme on "Operator algebras and conformal field theory", Vienna, Austria, September 8–19, 2008
- 5th European Congress of Mathematics, Amsterdam, The Netherlands, July 14–19, 2008
- Stieltjes educational week on non-commutative integration, Leiden, The Netherlands, June 9–13, 2008

SERVICE TO THE COMMUNITY

- Interim Chair of the *Mathematical and Theoretical Physics Group* of the Institute of Physics (IOP). (Since Sept. 2024), previously Treasurer of the group (2021–2024).
- Year 2 Tutor (School of Mathematics). Since 2024. Tasks include:
  - Provide oversight of Year 2 curriculum, academic guidance to students, and chair Exam Boards
  - Contribute to programme revalidation
  - Contribute to new programme development
- Academic Lead for Digital Learning (School of Mathematics), 2022–2024
- Member of *Quantum Materials* Interdisciplinary Doctoral Training Hub board (since 2023)
- Served as examiner/panel member for PhD defences of:
  - Samuel Hannah, Cardiff University, 20 August 2025
  - Lucas Affonso, Universidade de São Paulo, 25 July 2023
  - Alberto Ruiz de Alarcón, Universidad Complutense de Madrid, 19 January 2023
- Organised and co-organised the following seminar series and workshops:
  - 10^{th} AQFTUK Meeting, 5–6 June 2025, Cardiff
  - Topological Physics in Condensed Matter Theory, 12 April 2024, Cardiff
  - 6^{th} AQFTUK Meeting, 5–6 June 2023, Cardiff
  - Virtual LQP workshop, 17–19 June 2020, online
  - *Mathematical Physics and Probability seminar*, Winter 2017, UC Davis

  - *Anyons!* research group seminar, Spring 2016, and with Bruno Nachtergaele for Fall 2016, Winter 2017 and Spring 2017, UC Davis
  - *Mathematics Ph.D. Colloquium*, September 2008–May 2011, Radboud University Nijmegen
  - Ph.D. seminars on operator algebras and harmonic analysis (as co-organiser), 2009–2010, Radboud University Nijmegen
- Outreach activities:
  - supervised group of three high school students in *Siemens Competition in Science & Technology* (2016)
  - taught to high school students in Radboud University's *Sprint-Up* programme (2007–2010)
  - active on *Academia StackExchange* (since 2012)
- Referee for *Communications in Mathematical Physics*, *Forum of Mathematics: Pi*; *Journal of Mathematical Physics*; *Journal of Physics A*; *Journal of Statistical Physics*; *Letters in Mathematical Physics*; *Mathematical Physics, Analysis and Geometry*; *Reviews in Mathematical Physics*; *International Journal on Quantum Information*; *Quantum* (journals), *QIP 2014* (conference), ERC (grant proposals), and *Oxford University Press* (book)
- Reviewer for AMS *Mathematical Reviews* (until 2021)

MISCELLANEOUS

- Member of *International Association of Mathematical Physics*, *London Mathematical Society*, *Institute of Physics*.
- Languages: Dutch (native), English (full proficiency), German (upper intermediate), Spanish (intermediate), French (elementary)